



## AIR FORCE RESEARCH LABORATORY

### HCI Design Patterns for C2: A Vision for a DoD Design Reference Library

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# **HCI Design Patterns for C2: A Vision for a DoD Design Reference Library**



**SPAWAR  
Systems Center  
San Diego**

**24 January 2006**

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User-Centered Design

C2 Technology & Experimentation Division

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## Overview



- **Situation**: Human Computer Interface (HCI) critical factor in efficiency and effectiveness of modern Command and Control (C2)
- **Complication**: Cognitive Systems Engineering (CSE) lacks HCI design methodology
- **Implication**: Expensive custom designs, and uncertain outcomes, marginalizes CSE contributions in Systems Engineering projects
- **Solution**: Reusable HCI design patterns for C2 cognitive work
- **Benefit**: CSE delivers reusable HCI software, meeting affordability goals and assurance of HCI performance



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## DoD Requirement



- **Command & Control (C2)**

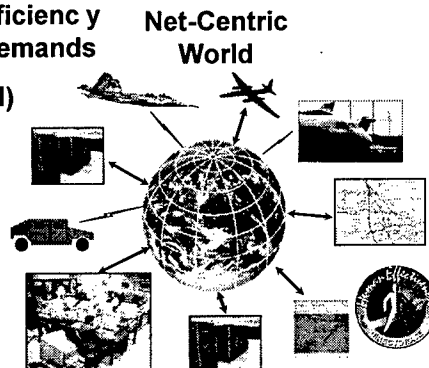
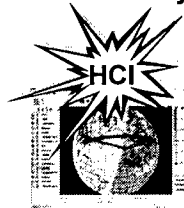
- Planning, coordinating, executing, monitoring, replanning



- **Network-Centric Operations**

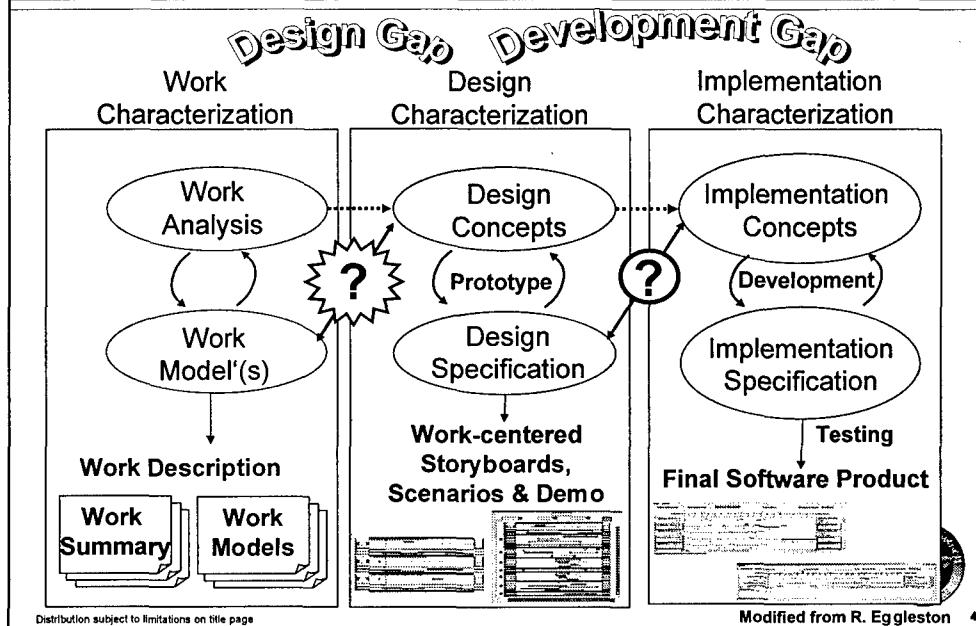
- Increased information access for C2
- Can increase effectiveness & efficiency  
But introduces new cognitive demands
- Human Computer Interface (HCI)  
critical element of system

Operator



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# Problem Gaps in HCI Design & Development

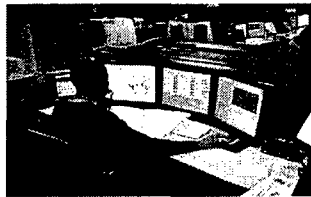




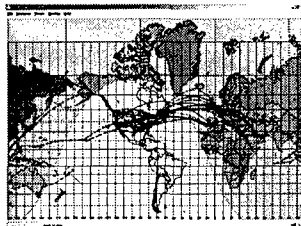
## Scientific Objective Methodology to Reuse HCI Designs



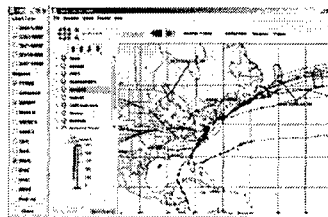
Technology already reused when meets AF requirements, so...



Similar  
  
Work



Tailored  
  
Reuse



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# HCI Design Patterns

## Assisting Common IT Interactions



### History of the Science foundation

- Origin in building architecture (Alexander, 1977)
- Software patterns to share coding approaches
- HCI Design Patterns
  - “...a structured textual or graphical description of a proven solution to a recurring design problem” (Borchers, 2001)
  - Several online pattern libraries (www.welie.com)
  - Framed around common interactions with a class of IT (web, desktop app, mobile device)

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### Website / Navigation: “Double-Tab”

Computers | Software & Accessories | Service & Support | Learning Center  
Main | Desktops | Notebooks | Handhelds | Hot Deals

### Desktop App / File Selection: “Preview”



### Mobile Phone: “Selection”







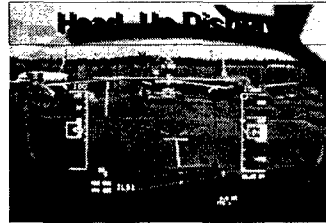
# HCI Design Patterns

## Assisting Complex Cognitive Work



### Work-Aiding Approach

- HCI design patterns assisting skilled task performance in operational domains
- Frame HCI design patterns around interactions with a "work field"
  - Work Function Types (Eggleson, 2002)
    - Decisions & typical problem cases
    - Collaboration
    - Product development
    - Work management
  - Context: Factors & Constraints
  - Work Field construct
    - Ecological Psychology (e.g., James Gibson, John Flach)
    - Cognitive Systems Engineering (e.g., Jens Rasmussen, Kim Vicente)



**Work Functions:** Control & monitor AC attitude, heading, & airspeed

**Contextual Factors:** Keep eyes on the sky, especially takeoff and landing

**HCI Solution:** Graphical & alphanumeric Information overlays cockpit view window

**Work-Aiding HCI Pattern?**

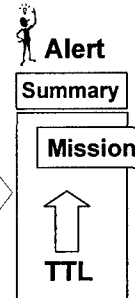
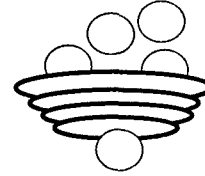
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## Identifying & Validating Patterns *Statistical vs. Content Basis*

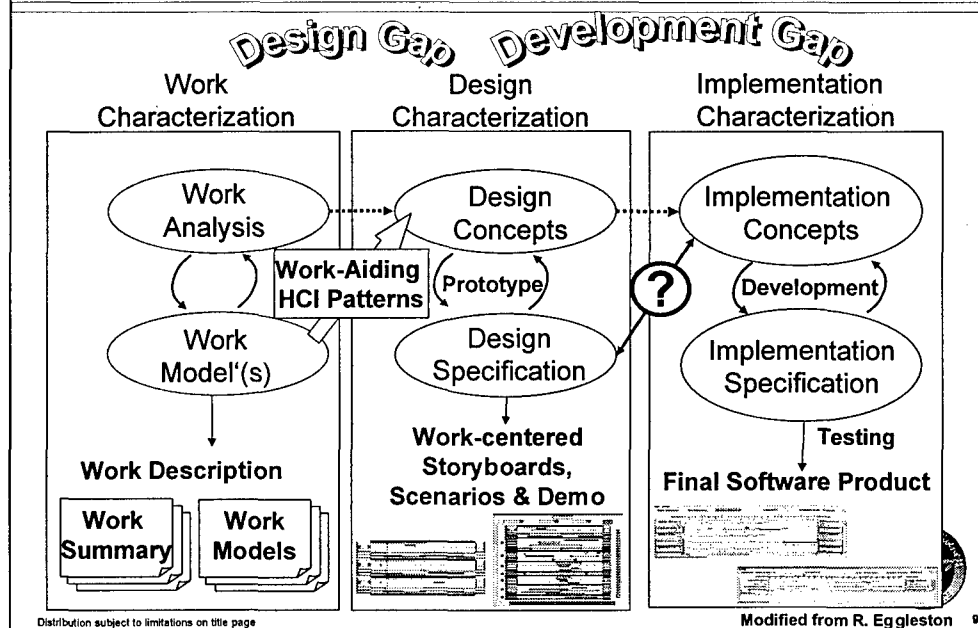


- Traditional HCI Design Patterns: Statistical validation based on large design sample size
- Work-aiding approach: Reverse engineer the few content-valid, cognitively-based C2 designs
  - Inductively reason HCI design patterns (general) from small number of examples (specific)
  - Decompose HCI design
    - Indirect aiding: Work Field Representations, Traditional HCI design patterns
    - Direct aiding: HCI automation patterns
  - Decompose work
    - Work functions supported by design
    - Work factors & constraints represented in design
  - Build hierarchy of C2 work functions, associate with work-aiding HCI design patterns



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# Strategic Approach Work-Aiding HCI Design Patterns





## Facilities



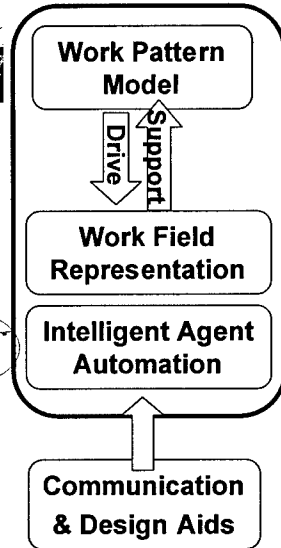
- **AMC TACC/XONI Integration Facility – Scott AFB**
  - Five HCI development projects to date
  - C2 operator access
- **HECS In-House Prototyping Laboratory**
  - HCI prototyping and human subject testing
  - Data feeds from AMC
  - Secure room



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# Technical Objectives



## • Models & Methodologies

- General theory of work
- Work pattern template
- Decomposing work-field representation
- HCI automation pattern catalog
- Validation, Verification & Accreditation

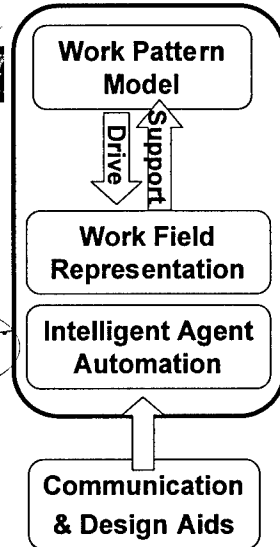
## • Communication & Design Aids

- Library of C2 work patterns
- Library of HCI Design Patterns...
  - Re-usable, work-aiding, flexible
  - Associated with C2 work patterns
- Software modules embedding design patterns
  - Plug-and-play in IDE
  - Tailorable HCI



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# Technical Objectives



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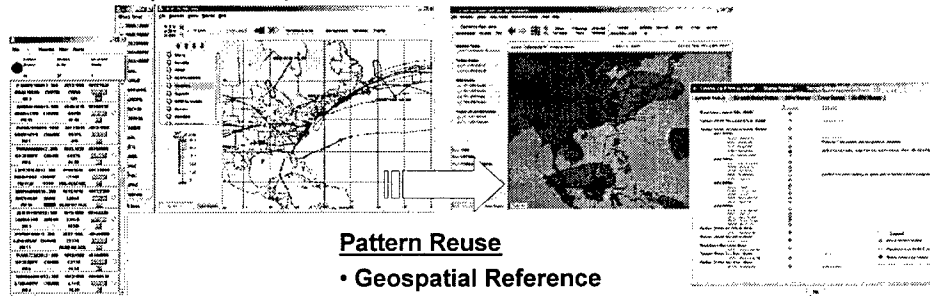
# Status Inductive Pattern Mining



## • Case: Air Mobility Mission Management

### Weather Hazard Monitoring (AMC/TACC)

### MAF/CAF Escort Mission Planning & Execution (AMC/TACC & ACC/AOS)



Multi-Mission  
Hazard Summary

### Pattern Reuse

- Geospatial Reference
- Aerial Routes
- Weather Overlays
- Airfield status
- Exception Reporting

Mission Planning  
Status



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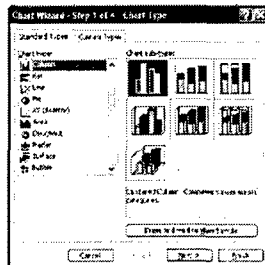
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## Vision for Design Tool

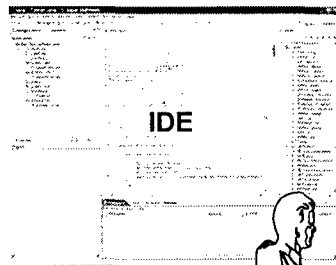


### • HCI Wizard within an Integrated Development Environment

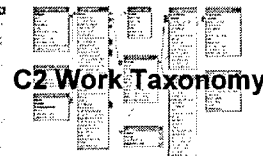
- Navigate C2 work function taxonomy
- Review potential, relevant HCI patterns per work functions
- Select, assemble, & populate HCI patterns for specific project
- Output: Notional HCI Design, Skeletal HCI Specification



MS Excel Chart Wizard



IDE



C2 Work Taxonomy



HCI Spec



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## Vision for Joint Operations

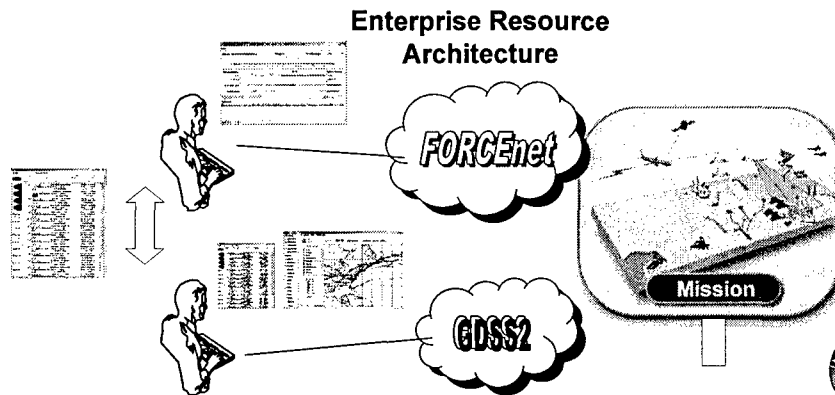


- DOD Pattern Library

“Flexible standardization” of HCI in C2

“Human interoperability” across armed services

Foundation for C2 training



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## Value to Stakeholders



- **Cognitive Systems Engineering (CSE)**
  - Establishes science of design through evolutionary C2 pattern development
  - Preserves work-aiding properties of HCI throughout product lifecycle
  - Incorporates legacy HCI guidelines, traditional HCI design patterns
- **Systems Engineering**
  - CSE delivers software: “plug and play” HCI designs developed in an IDE
  - System Engineers can anticipate human performance parameters associated with HCI
- **Program Managers**
  - Meets affordability through software reusability
  - Reduces project risk associated with HCI
- **C2 & Net-Centric Ops**
  - Assures HCI success in aiding human operator
  - Promotes human interoperability across distance, missions



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## Collaboration Past, Present, & Future



### • Past

- Northrop Grumman (Co-developed initial work-aiding approach)
- SRA (Four design patterns for Time Critical Targeting)

### • Present & Future

#### – SPAWAR

- DOD Pattern Library
- Joint design pattern methodology

**FORCEnet**

**GDSS2**

#### – HCI Reuse Case Study (HECS)

- Global Strike AOC, Barksdale AFB



**Commander's  
Predictive  
Environment**

#### – DOD HFE TAG

#### – Other DOD Agencies sought



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## Summary



- **Situation:** Human Computer Interface (HCI) critical factor of Net-Centric Command and Control (C2)
- **Complication:** Cognitive Systems Engineering (CSE) lacks HCI design methodology – “Design Gap”
- **Implication:** Expensive custom designs, and uncertain outcomes, marginalizes CSE contributions in Systems Engineering projects
- **Solution:** Methodology and library of HCI Design Patterns assisting C2 cognitive work
- **Benefit:** CSE delivers reusable HCI software embedded in development environment, meeting affordability goals and advancing human interoperability within joint missions

~ Invitation to Participate ~



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### Situation

- The concept of Net Centric Ops offers the opportunity for sharing information between distributed warfighters and systems like never before.
- C2 centers are a natural benefactor of NCO since, by design, they coordinate and direct operations that are distributed.

### Complication

- However, NCO is a double-edged sword for C2 centers. While it offers information sharing like never before, it creates new task demands of info management with the potential for warfighters to get lost in the sea of data.
- With NCO in C2 centers, the HCI becomes the gateway into the distributed network, with the dual job of accessing and presenting information in useful manner, while filtering out what is irrelevant.
- But currently, there are no established HCI solutions for command and control.
- There is also no standard methodology for translating the cognitive work requirements associated with C2 into work-aiding HCI designs for C2.

### Implication

- As a result, each HCI design for C2 tends to be one-of-a-kind solution. One-of-a-kind solutions means longer development time and cost. They also mean there can be no guarantee early in the stages of a design project that the finished product will assist human operators in their work within C2.

### Solution

- We advocate developing a library of HCI templates designed specifically to help with C2 operations. The HCI templates can be reused in different HCI design projects where the work requirements are similar.

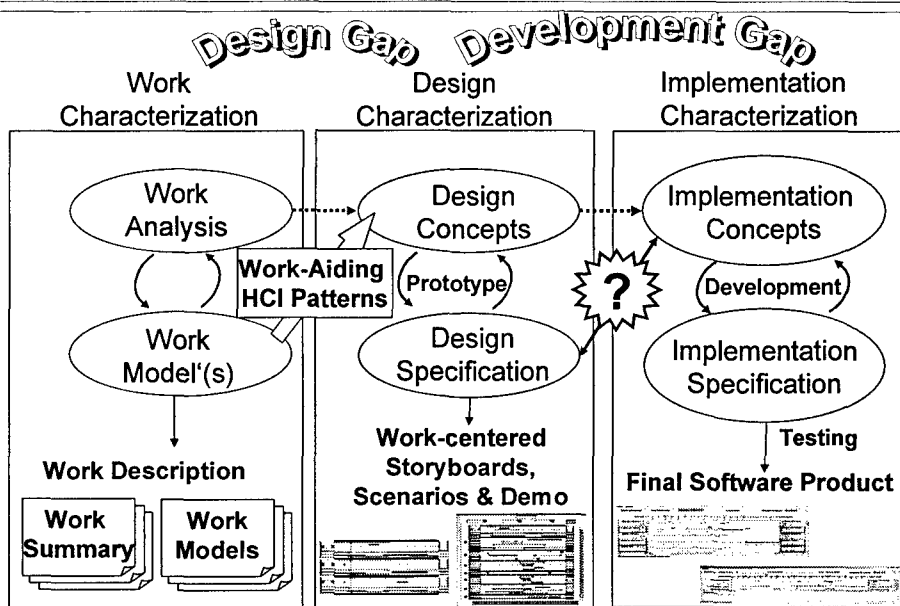
### Personal Introduction

- My name is Terry Stanard, and my background is cognitive systems engineering. Prior to joining the Human Effectiveness directorate, I worked for 6 years at Klein Associates investigating and modeling cognitive work requirements and recommending HCI designs in Army, Navy, and Air Force domains of operation.

### More Information

Cognitive systems engineering has collectively amassed enough experience modeling work and designing work-aiding HCIs, that we should be able to build a library of reusable HCI templates for C2. My goal for this presentation is to acquaint you with the problem and our approach, and attract your participation in this effort.

Reusable HCI templates can provide HCI designers with proto-designs that are known to assist human operators perform certain C2 work functions. They can reduce the HCI development time and increase assurance of a performance benefit to the HCI.





## Work-Aiding HCI Design Patterns



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